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The Need for Enterprise Architecture for Enterprise-Wide Big Data

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I. WHAT IS ENTERPRISE ARCHITECTURE?

Organizations today are confronted with an escalating variety of options to deal with an ever-faster changing environment resulting from the introduction of new technologies, the fusion of business and IT, the selection of novel business models, and the movement toward globalization. This environment demands enterprises to be innovative in adapting quickly to the requirements of the market while proactively exploiting the market situation to create new business opportunities (Land et al. 2009). Enterprise management in such a situation faces big challenges in making the right decisions at the right times. Enterprise management also needs solutions to deal with the complexity of business challenges in addition to the diversity of stakeholders and their concerns. To help business managers in decision making and dealing with the complexity of adaptation in their environment, a new practice is needed. The emerging practice of Enterprise Architecture promises to provide businesses with an overview of the enterprise, along with deep insights to address the complexity of challenges and keep up with the speed of an ever-changing environment (Land et al. 2009).

A. *The Use of the Term "Enterprise Architecture"*

Enterprise Architecture is defined and used in many ways and contexts today. The term can be used to describe the *process* of

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Enterprise Architecture, where the connotation is an action-oriented verb. Some people call this "Enterprise Architecting" to emphasize the process and action, but this variation of the term is not widely used. "Enterprise Architecture" is also used to describe the group or unit responsible for the Enterprise Architecture process in an organization. For the purposes of this paper, the group or unit that is responsible for the execution of the Enterprise Architecture process will be referred to as *the Enterprise Architecture practice* or briefly *Enterprise Architecture.* Another use of the term "Enterprise Architecture" is for the artifacts or outputs of the Enterprise Architecture process. In this context, Enterprise Architecture is used as a noun and is used to describe a collection of documents and other outputs. While this use of the term is understandable, for the purposes of this paper, the term Enterprise Architecture will be used to refer to *the process (verb)* (i.e., what it does).

Similar to this process-centric approach to Enterprise Architecture, Gartner defines Enterprise Architecture as the "process of translating business vision and strategy into effective enterprise change by creating, communicating and improving the key requirements, principles and models that describe the enterprise's future state and enable its evolution" (Lapkin et al. 2008). In this definition, the scope of Enterprise Architecture comprises people, processes, information, the technology of an enterprise, and their relation to one another and to the external environment (Lapkin et al. 2008). In fact, Enterprise Architecture produces tangible and pragmatic outcomes such as requirements, principles, and models that describe the next major stage of evolution of an organization, often called the "future state." Enterprise Architecture also produces an analysis of the gaps between the future state and the current state, and it creates the roadmaps that support the evolution of the enterprise to the future state by closing those gaps (Greefhorst and Proper 2011; Ross et al. 2006).

The output of the Enterprise Architecture process includes a holistic set of descriptions about the enterprise over time. The primary purpose of describing the architecture of an enterprise is to provide holistic information and insights needed for more effective decision making to improve the effectiveness, efficiency, and agility of an organization.

Enterprises undertake Enterprise Architecture for a variety of reasons. In some cases, enterprises want to perform better by doing things differently and they expect the Enterprise Architecture practice to enable that change. All of the future-state models, principles, and road maps will be for naught, however, unless they are actually implemented or become an ongoing part of enterprise operations.

This usually requires a robust governance mechanism that will ensure that Enterprise Architecture guidance is followed and that there is strong integration across business strategy, enterprise program management, and project portfolio management functions in order to ensure that common strategic goals are shared.

Some argue that the Enterprise Architecture practice is not really a new discipline but rather a collection of older, existing practices. In many respects this is true. Just as many of today's established professions evolved from a collection of practices, Enterprise Architecture is in the process of consolidating, enhancing, and adding structure to many practices that have been performed to different degrees in organizations for decades. As the Enterprise Architecture practice evolves into a more formalized profession, the link that Enterprise Architecture could, and many would say should, have with enterprise strategic planning is beginning to be better understood in many organizations today.

The Enterprise Architecture profession has often turned to simple comparisons to explain itself. In discussions with Enterprise Architects, the analogy used most frequently is the comparison of an Enterprise Architect to an Urban Planner. As Figure 1 implies, the Building Architect is analogous to the Solution Architect in that both typically are concerned with the construction of a single entity or system. However, the Urban Planner is somewhat analogous to the Enterprise Architect in that the Urban Planner needs to understand what the Building Architect (Solution Architect) does, but also needs to understand a wide range of topics that the Building Architect doesn't need to deal with – things like the vision of how the city should evolve, the safety and livability of the city, city infrastructure capacity and modernity, city systems interactions and integration, and many other areas.

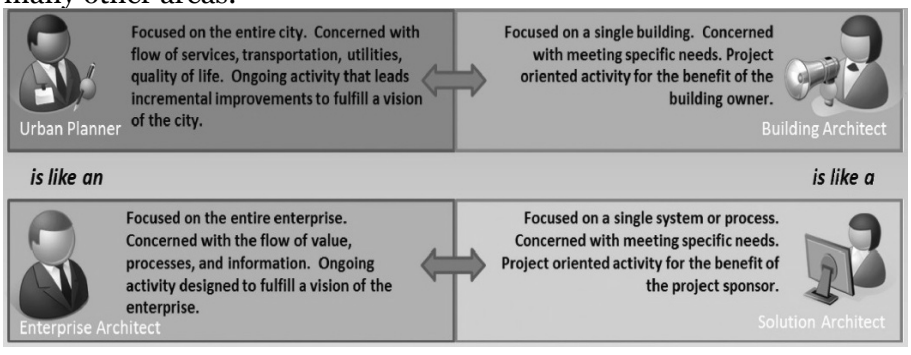

Figure 1: Urban Planning Analogy adopted from (FEAPO 2013)

In many respects, Enterprise Architects are the Urban Planners for an enterprise. While this is not a perfect analogy, many architects have been successful using this analogy to explain what the Enterprise Architect contributes to the enterprise. For better clarification,

Table 1 compares each of the four roles discussed above based on the scope of activity, stakeholders involved, requirements, values, life span, governance, and key challenges.

	Holistic View		**Single View**	
	Urban Planner	**Enterprise Architect**	**Building Architect**	**Solution Architect**
Scope	Entire city	Entire organization	One building	One system
Stakeholders	City leaders	Business leaders	Building owner	Business manager
Requirements	Visionary	Strategic	Specific	Specific
Value	Incremental and continuous	Incremental and continuous	Valuable when completed	Valuable when completed
Lifespan	Evolves with the life of the city	Evolves with the life of the organization	Rarely updated	Rarely updated
Governance	Citizen involvement	Stakeholder involvement	Command and control	Command and control
Key Challenge	Managing continuous change	Managing continuous change	Standards and high quality	Standards and high quality

Table 1: Detailed Comparison of Roles in Urban Planning Analogy

As Enterprise Architecture matures in an organization, the activities and scope of the Enterprise Architecture process often extend into what is sometimes known as the "extended enterprise." According to Wikipedia, "An extended enterprise is a loosely coupled, self-organizing network of firms that combine their economic output to provide products and service offerings to the market. Alternatively referred to as a 'supply chain' or a 'value chain,' the extended enterprise describes the community of participants involved with provisioning a set of service offerings," ("Extended Enterprise").

B. *Traditional and Evolving Views of Enterprise Architecture*

When discussing Enterprise Architecture, an understanding of both the traditional and the evolving scope of Enterprise Architecture activities in organizations is helpful. It is important to note that this paper presents general trends in the field that may not fully apply to specific organizations or situations. The scope of Enterprise Architecture in some organizations today is evolving to encompass the architecture of the enterprise as a whole, which is broader than the traditional use of Enterprise Architecture. However, traditionally Enterprise Architecture has referred to an enterprise-wide architecture for only the enterprise's information technology (IT) assets (De Vries and Rensburg 2012). Today, this approach is sometimes referred to as Enterprise Information Technology Architecture (EITA) or Enterprise Information Systems Architecture (EISA). While there is growing interest in the application of architectural thinking to enterprise domains other than IT, it is important to recognize that the majority of Enterprise Architecture practices today are primarily focused on IT-related assets and functions.

The practice of Enterprise Architecture has its foundations in IT, and there are several popular enterprise frameworks and methodologies that have been developed for EITA (or EISA) which target the alignment of IT assets and capabilities with the enterprise's mission and strategy. Most of these frameworks and methodologies provide guidance on the formation of a comprehensive set of integrated models that describe the structure and IT functions of an enterprise. These models have important uses in systematic IT planning and architecting. The individual models produced in the Enterprise Architecture process are arranged in a logical manner, and this provides an ever-increasing level of detail about the enterprise, including: enterprise objectives and goals; enterprise processes and organizational structure; enterprise systems and data; and enterprise technology used.

In some cases, Enterprise Architecture practices may focus on the outputs, ("the noun") rather than the process of Enterprise Architecture. In these cases, practitioners mistakenly tend to be more concerned about producing a predefined set of deliverables than they are about meeting the strategic imperatives of the enterprise. This single-minded focus on deliverables is problematic because it can lead to unnecessary "artifacts" (requirements, models, principles, guidelines, standards) that are not demanded by the strategic imperatives or processes of the enterprise and are therefore not widely

used. Focusing on Enterprise Architecture as a continuous process allows the Enterprise Architecture practice to evolve and provide desired business outcomes and continuous clarity about the ongoing transformation of the enterprise.

Many of the frameworks and methodologies designed for EITA follow the general process outlined in Figure 2.

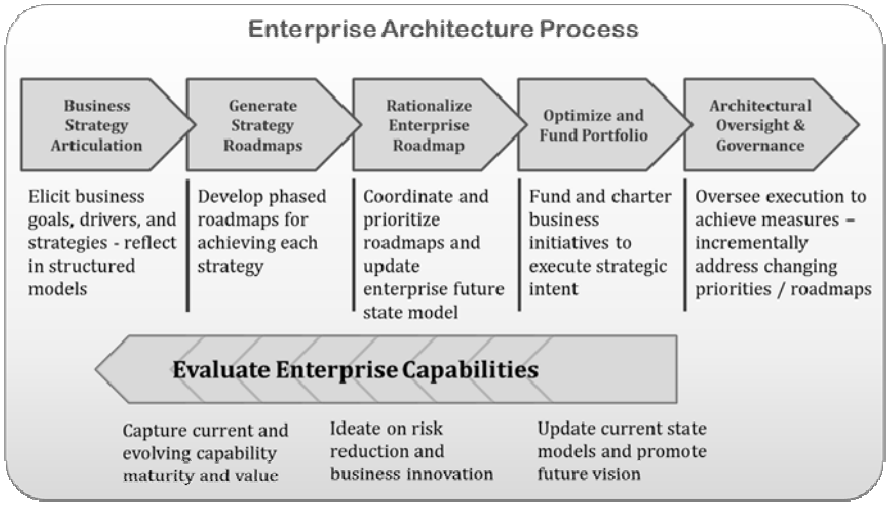

Figure 2: General Enterprise Architecture Process

1. *Areas of Focus in Traditional View of Enterprise Architecture*

Many Enterprise Architecture frameworks break down the practice of developing and using the outputs of the Enterprise Architecture process into four traditional areas of focus (TOGAF 2006; Platt 2002; FEAPO 2013; Cameron 2013). This approach allows the enterprise to be described from four interconnected viewpoints. By taking this approach, enterprise architects provide better assurance to their business stakeholders that they have provided sufficient information for effective decision making. These traditional areas of focus are as follows (Cameron 2013):

1. **Business:** Strategy maps, goals, objectives, corporate policies, operating model; functional decompositions, capabilities, and organizational models; business processes/rules, value streams; organization cycles, periods and timing; and suppliers of hardware, software, and services.

2. **Applications:** Application software inventories and diagrams; interfaces between applications, e.g. events, messages and data flows; and intranet, Extranet, Internet, E- Commerce, EDI links with parties within and outside of the organization**.**

3. **Information/Data:** Metadata, i.e. data that describes your enterprise data elements; data models: conceptual, logical, and physical; business domains, business entities, data elements, relationships; and data requirements.

4. **Infrastructure/Technology:** Hardware, platforms, and hosting, e.g. servers and where they are kept; local and wide area networks, Internet connectivity diagrams; and operating systems/software platforms; infrastructure software: application servers, DBMS; and network and communications infrastructure.

The value of Enterprise Architecture is not in handling only one area of focus described above; rather, value comes from managing the relationships, interactions, and interdependencies among the areas (Platt 2002). Hence, effective Enterprise Architecture should capture the current and future states of the enterprise in these four areas of focus in order to execute the business strategy. Figure 3 illustrates the close relationship between the areas of focus described above.

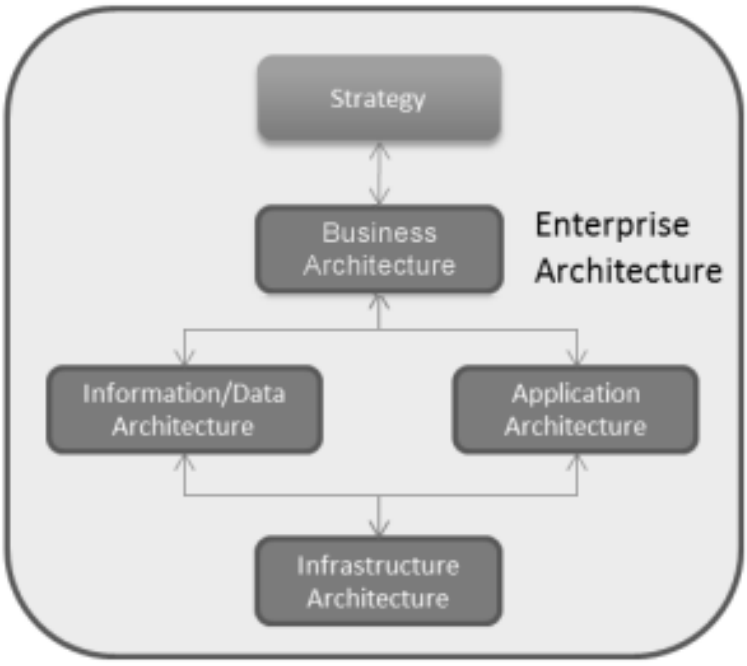

Figure 3: Traditional Enterprise Architecture Focus Areas

While these four areas of focus are traditional breakdowns for analysis, they falsely imply that business understanding is approximately one quarter of the process or one quarter of the importance. These four areas of focus are useful for conducting enterprise analysis, but it is important to note that Enterprise Architecture is a business issue, not a technology issue. As mentioned previously, the primary purpose of describing the architecture is to improve the effectiveness or efficiency of the enterprise. To reflect this perspective, many feel that the business side of the equation requires equal prominence (some might say greater prominence) as the IT side of the equation. Figure 4 illustrates the general Enterprise Architecture process and the traditional areas of focus.

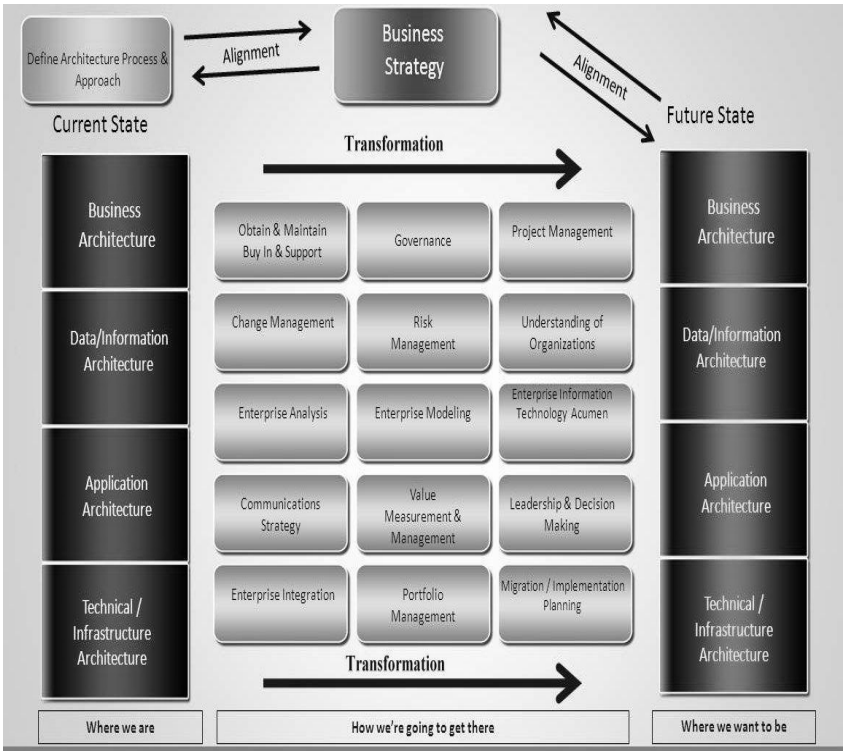

Figure 4: General Enterprise Architecture Process and Traditional Focus Areas

An important element of the Enterprise Architecture function is its potential as a mechanism for transformational change in an organization. Transformation is a continuous process and is about making fundamental changes in how business is conducted, often triggered by a shift in external influences like the market environment, customer expectations, or competitive opportunities. Enterprise transformation is typically achieved by realigning the way staff perform their functions, how the organization is structured, and how technology is used toward a new strategic direction. Enterprise Architecture provides the iterative processes needed to analyze, design, plan, and successfully implement enterprise transformation efforts.

As a continuous process, transformational change may take several forms encompassing one or more of the traditional Enterprise Architecture focus areas mentioned, as well as interactions among those areas. Enterprise Architecture facilitates these processes by explicitly stating requirements, spelling out future states, and suggesting ways to better align all aspects of the organization with

changes in strategy. Without the type of enterprise-wide analysis, design, and planning that is typical of Enterprise Architecture, large scale change and transformation is very difficult to successfully achieve. The Enterprise Architect (and the Enterprise Architecture team) should be a leader of transformation in the enterprise and an integral part of the business decision making process. This is not the case in many organizations today, but this is where the field is moving. Effective leadership, decision making, and communication skills will be needed to evolve the Enterprise Architecture practice to this role in an organization.

2. *Areas of Focus in Evolving View of Enterprise Architecture*

As mentioned previously, the scope of Enterprise Architecture in some organizations today is evolving to encompass the architecture of the enterprise as a whole. There is a growing need for the Enterprise Architecture frameworks and methodologies that originated in the IT domain to evolve and extend, becoming less IT-centric in order to be of use to the rest of the enterprise. Recognizing this need, Leonard Fehskens, Editor of the Journal of Enterprise Architecture, is developing a forward-looking version of the traditional Enterprise Architecture focus areas. The goal of this work is to show a possible future direction and vision for Enterprise Architecture that moves from the IT-centric nature of the traditional Enterprise Architecture focus areas to instead evolve these areas using terms and concepts that are familiar to all areas of the enterprise. Figure 5 shows the evolution of Enterprise Architecture from traditional areas of focus to the new non-IT-centric focus areas.

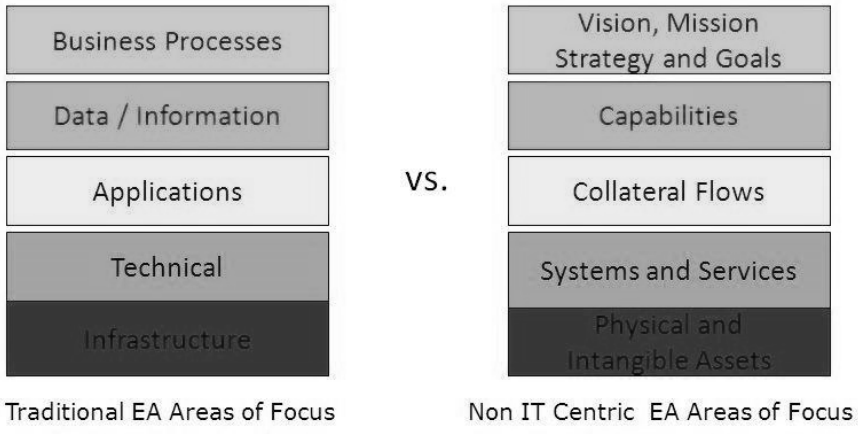

Figure 5: A Forward Looking Vision of the Enterprise Architecture Areas of Focus

The areas of focus in the Fehskens model are as follows:

- **Vision, Mission, Strategy and Goals**: The enterprise-wide vision, mission, strategy and goals that the business capabilities support.

- **Enterprise Capabilities**: The integration of multiple systems and services and the collateral flowing within and between them into enterprise capabilities.

- **Collateral Flows**: Generalizing information to everything that flows within and between the enterprise's systems and services.

- **Systems and Services**: Generalizing IT applications to all the systems and services built up from the physical and intangible assets of the enterprise.

- **Physical and Intangible Assets**: Generalizing the physical (HW infrastructure) and intangible (SW infrastructure) assets of the IT organization to the entire enterprise.

Figure 5 is representative of the need to evolve many of the traditional IT-centric Enterprise Architecture models and frameworks in order to have enterprise-wide applicability.

II. THE VALUE ENTERPRISE ARCHITECTURE BRINGS TO AN ORGANIZATION

Enterprises face many changes, such as mergers, acquisitions, novel technologies, and growing global competition, that contribute to an increasingly dynamic environment in which enterprises need to thrive (Land et al. 2009). It is no wonder that the ability to cope with organizational change has become a competitive edge in today's business economy (Wood 2010). In essence, enterprises need to formulate their business strategies constantly, based on the changes required by their environment, in order to conform with the required agility and fulfill their business objectives. However, in practice, enterprises may see themselves hampered in their ability to execute strategies in several ways, such as: 1) being uniform in their own internal structures, capabilities, products, and services; 2) lacking common governance and shared understanding of key enterprise data resources; 3) organizational silos and separate business units which work on their own with no data sharing; 4) application silos in which applications provide functionality only to specific business processes; and 5) prevailing organizational regulations and structures that have become ingrained in the social, technical, and cultural aspects of an enterprise (Land et al. 2009).

The road from strategy planning to strategy execution is definitely not an easy one to travel. Strategic planning alone does not directly produce a measurable return on investment (ROI). Rather, successful execution of the strategic plan in the form of projects that are well aligned with the strategic plan will produce benefits on many levels to the enterprise (FEAPO 2013). Research shows that less than 60% of enterprises' strategic objectives are achieved, and this failure calls enterprises to look for practices that enable them to do the right things (be effective) and do things right (be efficient) in strategy execution (Land et al. 2009). The role of Enterprise Architecture as the necessary bridge between strategy and execution is illustrated in Figure 6.

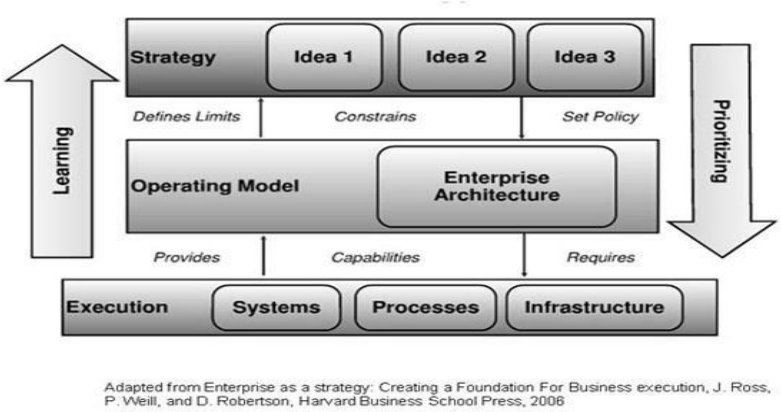

Figure 6: Enterprise Architecture as the Bridge between Strategy and Execution

To elaborate on what the intermediary role of Enterprise Architecture means in terms of executing business strategy, let's go back to the urban planning analogy shown in Figure 1. The mayor and city council (the C-level executives) work with a strategic planning group to develop a strategic plan for the city. The Urban Planner then works closely with elected officials, civic leaders, civil engineers, building architects, and community groups to help develop and implement the city's strategic plan over time. Without the urban planning team as the bridge between the strategic vision and the people who implement aspects of the strategic plan (building architects, road and infrastructure architects, engineers, etc.), there would be little or no coordination at the implementation level and no city-wide analysis, design, and planning to ensure effective and efficient implementation of the city's strategic plan. Similarly, the application of Enterprise Architecture delivers significant business value to the enterprise by producing results including but not limited to (FEAPO 2013):

- An articulation of enterprise strategic requirements;

- Models of the enterprise future state which illustrate what the enterprise should look like across all the focus areas of Enterprise Architecture to support business strategy;

- A roadmap of the change initiatives required to guide enterprise transformation to its future state; and

- Development of requirements, standards, guidelines, and principles that steer the implementation of change initiatives to reach the future state.

While these results articulate the business value of applying Enterprise Architecture, its contribution to various aspects of enterprise management and strategy execution includes but is not limited to (FEAPO 2013):

- Improving effectiveness, efficiency, and agility of the enterprise;
- Bringing innovations to the structure of an enterprise;
- Improving the capability of enterprise continuous innovation as well as change management competency;
- Rational centralization and federation of enterprise business processes;
- Improving the quality of enterprise information and its timeliness;
- Articulating and clarifying business rules; and,
- Aligning the money spent on business initiatives and systems so that it actually justifies its strategic intent.

In many organizations today, the scope of the Enterprise Architecture practice is primarily or solely in the IT area. If the Enterprise Architecture practice is positioned inappropriately in the organization, the Enterprise Architecture practice may be viewed as little more than the IT planning group and not viewed as a bridge between strategy and execution. Typically, Enterprise Architecture groups need to first prove their understanding of the business and strategy and their ability to link strategy with execution in the IT area before gaining the confidence and approval needed to expand the scope of their operations to the enterprise as a whole.

One of the common approaches for business strategy execution is to have Enterprise Architects define the future state of the enterprise and define a set of intermediate steps called a "transitional architecture," which illustrates the transformation process of the enterprise from its current state to future state. In short, when

Enterprise Architecture is applied correctly to an enterprise, strategic needs are analyzed, planned, designed, and implemented in an effective, efficient, and consistent format. Where Enterprise Architecture is not utilized in an enterprise, this implies that the needed bridge between strategy formulation and strategy execution either does not exist or is fragmented (FEAPO 2013).

A. *What is Big Data?*

Due to the rapid proliferation of data available to be analyzed, businesses are undergoing a revolution driven by the use of data and analytics to guide their decision-making (Gopalkrishnan et al. 2012; Singh and Singh 2012). IBM estimates that 2.5 quintillion bytes of data are created every day -- so much that 90% of the existing data in the world has been created over the last two years (Singh and Singh 2012). In fact, the evolution of storage media in size and the rapid decrease in its cost have been factors encouraging the recording of more detailed data in every business, which has ended up in today's "data tsunami" (Nair and Narayanan 2012).

A huge volume of data is generated every day from different resources such as posts on Facebook, Twitter, and YouTube, cellphone conversations records, etc., and leading organizations increasingly to realize that big data is a significant strategic asset that they can leverage for better decision making in a growing competitive business environment (Gopalkrishnan et al. 2012). Some organizations use data analytics to improve the quality of their customers' experience by measuring and acting on the sentiments they express (Gopalkrishnan et al. 2012; Tien 2013). Others use data analytics to predict their customers' propensity for buying new products in order to proactively recommend upcoming products or to offer discounts, both of which encourage a long-term relationship with customers (Gopalkrishnan et al. 2012). Simply stated, big data creates business value by enabling organizations to uncover previously unseen patterns and to develop clear and sharp insights about their business environment. Big data also enables innovation, productivity, and growth for organizations that struggle with tight budgets and continued economic uncertainty (Newman 2012).

The concept of "Big Data" originally meant a high volume of data that traditional relational databases could not process efficiently. The original definition mainly focused on structured data, but after a while practitioners and researchers recognized that most of the world's data resides in massive unstructured format that is largely in the form of imagery and text (Kaisler et al. 2013). In this regard, Nair and

Narayanan (2012) predict that 68% of all digital data in 2015 will be in unstructured format.

Although there has not been a commonly accepted definition for big data, people usually believe that big data is the amount of data which is beyond the capability of technology and software tools to capture, manage, and process efficiently (Chen et al. 2013; Kaisler et al. 2013; Madden 2012). Researchers have summarized the most important aspects of big data in following "three V's" (Singh and Singh 2012; Chen et al. 2013; Kaisler et al. 2013; Katal et al. 2013; Madden 2012; Beyer et al. 2011):

- **Volume:** the size of existing data is in petabytes, which is supposed to reach zettabytes in the nearby future. Such an amount of data is definitely difficult for traditional systems to handle.

- **Velocity:** the speed of the data flow coming from various sources is very high, while it is constantly changing. Velocity means both how fast data is being generated and how fast data must be processed to meet the business demand. Traditional systems are not capable of performing analytics on such data which is permanently in motion.

- **Variety:** the data produced by various sources is not of a single type, as it includes raw, structured, semi-structured, or unstructured data. Hence, such inconsistency of data formats has made it difficult for traditional database systems to analyze it.

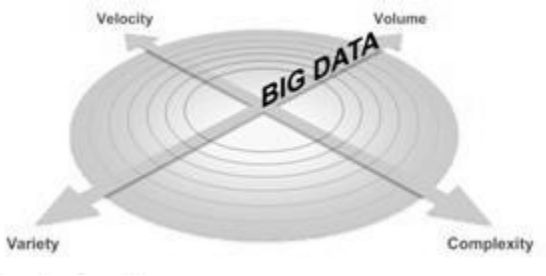

Figure 7: Important Aspects of Big Data Adopted from (Beyer et al. 2011)

Some authors also consider complexity to be a characteristic of big data (Katal et al. 2013; Beyer et al. 2011). Complexity means that different domain rules, standards, and even storage formats are associated with each asset data type, which means it is quite an

undertaking to link, match, cleanse, and transform data coming from variant sources across systems (Beyer et al. 2011; Katal et al. 2013). Figure 7 shows how big data is composed of the four characteristics discussed above.

Big data is composed of both machine-generated and human-generated data. Examples of machine-generated data are call detail records, data produced by manufacturing sensors, equipment logs, data produced by vehicle tracking systems, and so on, whereas human-generated data includes customer feedback streams, social media platforms, images, documents, video files, call logs from CRM systems, and data from direct interactions with employees, suppliers, and customers (Oracle 2013). As the growth of data generated by different resources is increasing, the major challenges for enterprises have become to: 1) design an appropriate system that handle the data effectively, and 2) analyze big data to extract insightful meaning for decision making (Kaisler et al. 2013; Bakshi 2012). In this regard, statistics from a survey conducted by Infochimps shows that 81% of enterprises, ranging from small to large companies, consider big data analytics projects as a top-five IT priority (Kaskade 2013).

Although enterprises have realized that big data is a strategic asset, statistics shows that 55% of big data projects aren't completed, and many others fall short of their objectives (Kaskade 2013; Eastwood 2013). Many companies blindly build out complex databases and start to collect data based on a vague plan without knowing what they really want out of big data, which mostly leads to failure.

B. *Issues with Enterprise-wide Big Data Implementations*

Organizations today are very complex and they have been capturing a large volume of data for years, often in a variety of nonstandard formats located in isolated silos around the enterprise (Oracle 2013). The data of complex and extended enterprises, including data from suppliers, customers, and other sources, usually resides in different sections and departments, which makes silos of data that are hard to integrate. Figure 8 illustrates the organizational silos of extended enterprises and the data silos which reside in them.

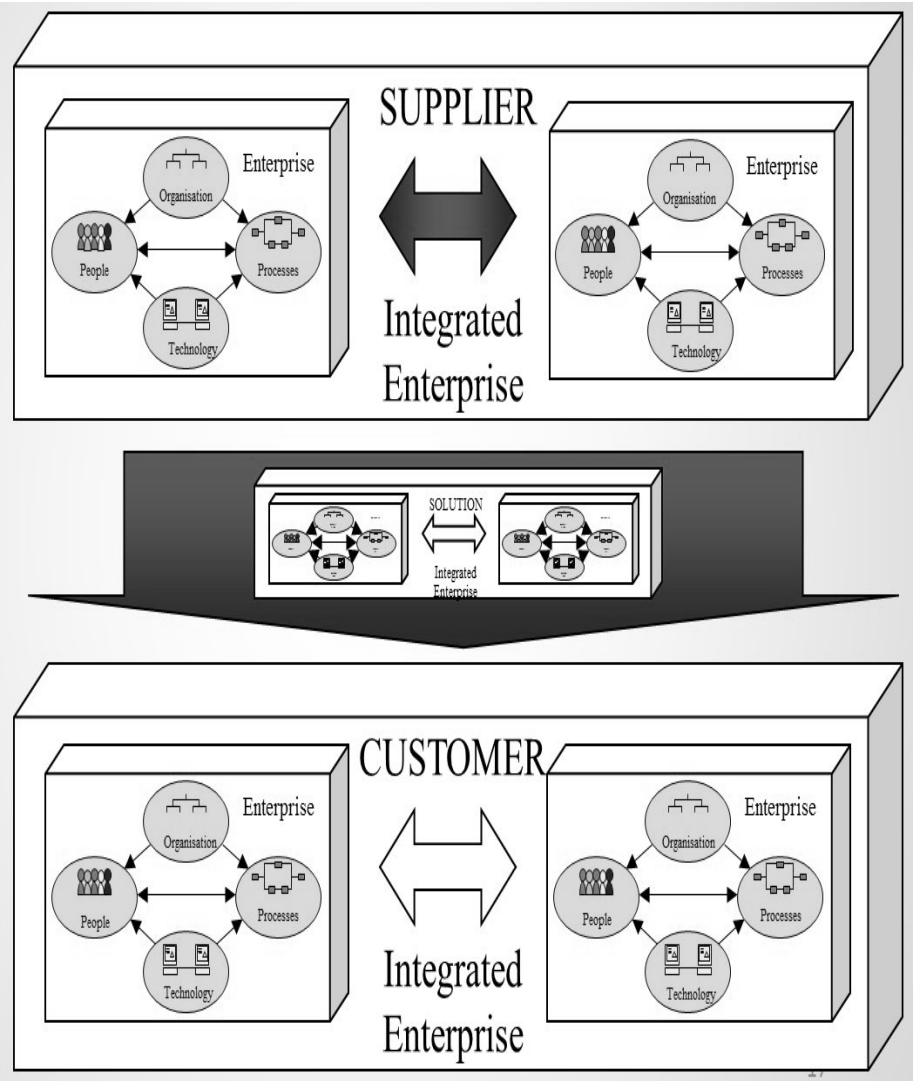

Figure 8: Data Silos in Complex and Extended Enterprises

The challenge of big data projects today is finding an effective, timely, and cost-efficient way to make big data accessible so that managers can use and analyze it in conjunction with enterprise data to get more insights about the business (Oracle 2013). Similar to IT projects, the implementation of big data projects aimed at supporting existing products or services of an enterprise requires capturing and understanding business requirements, careful planning, collaboration with stakeholders, thorough testing before rollout, training, and

support (McDonald and Sipp 2013). However, the current literature on big data predominantly focuses on the technical issues of providing a platform for big data analytics rather than issues of big data project management. Hence, this report discusses several of the root causes related to project management that can cause the failure of big data projects in complex enterprises.

1. *No Business Goal and No Alignment with Business Requirements*

There is a consensus among authors that the failure of big data projects is mostly due to not having a clear business goal in the initial steps of the project (Eastwood 2013; Bartik 2013; Zhu 2013; Kaskade 2013). Many big data projects are started very quickly before there is a business driver or requirement behind them (Bartik 2013; Zhu 2013). Even within a broader domain of IT projects, research shows that the lack of clear business objectives for IT projects has been one of the paramount factors which prevents projects from delivering their intended functionality according to their estimated time and schedule (Johnson et al. 2001; Fichter and Cervone 2003; Glaser 2004; Kappelman et al. 2006; Schmidt et al. 2001). In essence, when a sound business case is not defined for an IT project, the business requirements of the project have also not been met (Schmidt et al. 2001; Kappelman et al. 2006), and in consequence the business value delivery of the project is missed.

Similar to other IT projects, it is necessary for enterprises to define what the outcomes of the big data project will be, who will benefit from it, and how they will benefit. Hence, as long as big data projects are considered to pose purely technical issues, the failures will continue to pile up. Getting the platform running for big data projects is not a big issue, but the shortcoming is that core decision makers and end-users cannot extract value from the mass of information because they do not know exactly what they are looking for (Zhu 2013; Bartik 2013).

Big data projects also suffer from the lack of output alignment with business requirements, as do other IT projects (Eastwood 2013). Meeting the time and budget goals of projects is no longer sufficient for project success; instead, the proper alignment between the project management process and the business strategy is the most important dimension for project success (Alsudiri et al. 2013). In many organizations, large projects have been executed with no strong link to the business goals and business strategy, and such misalignment has led to 30% of all projects' failure (Alsudiri et al. 2013; Miller 2002).

Therefore, achieving alignment between big data project outcomes and organizational goals becomes challenging if the objectives of the business strategy are not clear or communicated to big data project managers. Such misalignment causes big data projects to miss achieving their goals (Alsudiri et al. 2013).

2. *Poor Planning and Failure to Recognize Project Scope*

Researchers believe that a second reason behind big data project failure is poor planning, which gets big data projects into trouble (Eastwood 2013; Gasper 2012; Kaskade 2013). This factor is not limited to big data projects and, in the larger scope of IT projects, appropriate planning is considered key to avoiding project failure (Vandersluis 1997; Camilleri and Corporation 2010; Kappelman et al. 2006). In most cases of project failure, IT managers are not given enough time to focus on planning due to time pressure from senior managers, and in consequence IT projects are started before their objectives are fully defined (Kappelman et al. 2006). Planning in IT projects is an important phase which gives project managers the opportunity to sit down and think about what the project is all about and how it is supposed to be achieved. What are the deliverables of projects and when are they due for submission? What skills are necessary for task accomplishment and where can those skills be obtained? What are the obstacles likely to be encountered and how can they be tackled? What are the risks involved and how can they be managed (Cadle and Yeates 2007)? In fact, project planning gives project managers and stakeholders a clear idea of where they are going by providing a tangible demonstration of thoughts that are put into action through resource, time, and budget allocation (Cadle and Yeates 2007). Hence, in big data project management, as in other IT projects, well-defined planning is a necessity for achieving business requirements, and poor planning may result in poor delivery and project failure.

One of the other concerns in managing big data projects is the lack of defining an adequate and clear scope, which is directly linked to vague project goals (Kaskade 2013). The scope of a project is defined as part of the project planning that involves determining and documenting a list of specific project goals, deliverables, tasks, costs, and deadlines (Rouse 2012). Many studies consider ill-defined and inaccurate project scope to be the top-ranking cause of failure in IT projects (Reel 1999; Kappelman et al. 2006). In fact, implementation of enterprise-wide IT projects, such as big data, require the satisfaction and involvement of multiple classes of stakeholders in an

enterprise, from IT managers to senior executives. If IT managers and business executives do not come to a consensus on the scope of a big data project, it can easily shoot off into many directions, shifting the focus from answering specific questions to managing the technology needed for achieving everybody's piece of the pie (Bartik 2013). Therefore, in the case of big data projects, there must be adequate scope definition for the project across multiple departments of an enterprise in a collaborative manner (Mcfarlane 1993).

3. *Lack of Access to Data and Lack of Communication between Stakeholders*

Big data experts encounter challenges in accessing the internal data of an enterprise when they want to bring the external and internal data to the same platform for analysis. These difficulties can be traced to the tendency toward information silos in organizations, which prevents big data experts from accessing all of the data enterprise-wide for conducting analysis in conjunction with aggregated data outside the boundary of organization (Bartik 2013; Brobst 2013; Kaisler et al. 2013; Newman 2012a). If a big data repository is to be used for making accurate and timely decisions, the data must be available in a complete, accurate, and timely manner (Katal et al. 2013). However, many studies show that organizations have siloed the ownership of data into different business units such as marketing, sales, and HR, which barely communicate with each other, hindering them from having cross-access to each other's data on an enterprise scale (Grigoriu 2011; Wood 2010; Kaskade 2013; Gasper 2012).

One reason for the dominance of information silos in organizations is the lack of stakeholder trust and confidence in the accuracy, integrity, and usefulness of data. Stakeholders in such organizations may not share their data and may hoard their versions of it, which causes issues with efficiency and compliance (Newman 2012a). If the organizational culture is mired by information silos, they are less likely to achieve success with big data, despite having the best technology and the best people. Therefore, addressing cultural challenges requires creating the right incentives for building trusted sources that share enterprise information (Newman 2012a).

Another reason for the dominance of information silos in organizations is that users are concerned only about solving their own business problems by creating their own information artifacts without caring about data consistency issues. The tremendous popularity of spreadsheets is the result of working in data silos that provide power

to users, allowing them to customize and organize information in a way that helps with their own particular tasks. Seen from an enterprise point of view, these spreadsheets and other customized data files are a problem since there is no way to make sure they are consistent or to take advantage of them at the enterprise level. At best, they are valuable information assets not being used to their full potential and, at worst, they become barriers to creating comprehensive systems (Wood 2010). Hence, it is a high priority for enterprises to create a unique information infrastructure to serve consistent data across the enterprise and solve the data access problem in big data projects.

In enterprise-wide projects, such as big data projects, the lack of communication between IT and business unit stakeholders is another factor that has a negative impact on project success (Kaskade 2013). In fact, any significant enterprise-wide project has multiple stakeholders and requires the choreography of tasks and resources among them. Changes across the life of large projects are inevitable, and if stakeholders across different departments do not communicate on an ongoing basis, project managers will not know how to drive the project though the new changes required. If consensus on clear criteria for the project's success among stakeholders is lacking, then there is little hope of completing the project on schedule or perhaps completing it at all (Kappelman et al. 2006).

4. *Change Management Issues*

A big data project may encounter challenges if it requires changes in the business processes of an enterprise that feel too foreign to the business stakeholders (Bartik 2013; McDonald and Sipp 2013). In such a situation, stakeholders may become reluctant to accept change or dismiss it as a faulty process change (Bartik 2013). Stakeholders' resistance to change and their lack of involvement with new trends happens not only to big data projects, but it has also been reported as one of the causes of failure in IT projects generally (Reel 1999). In fact, every change in an enterprise occurs in three aspects: process change, technology change, and people change. Although enterprises may overcome managing process and technology changes, many fail to assess the impact of change on people, who are a critical component of implementing changes in an enterprise (Dreyfuss 2005). Therefore, business process changes required for big data project implementation may have sub-optimal outcomes due to the resistance of business process stakeholders.

5. *Focus on Technology Rather than Business Opportunities*

Many big data projects get stuck in the trap of testing technology rather than uncovering business value from it. Enterprises unfortunately place a lot of focus on the three Vs of big data: Volume, Velocity, and Variety, rather than the most important V, which is value. For example, downloading open source software from the Apache website and experimenting with Hadoop are interesting programming exercises, but they are unlikely to yield business results. Therefore, without business direction in seeking insight, even using the latest technologies of big data analytics is bound to fail (Brobst 2013).

Even in the larger scope of IT projects, David Gardner (2000) believes that understanding the business needs that a software application must support in an enterprise is important to avoid project failure. For instance, in the case of implementing an enterprise-wide project such as Enterprise Resource Planning (ERP) systems, comparing the features and functionalities of competing ERP vendors' packages does not bring any value to the enterprise unless senior managers define how they want to run their business with the ERP package. Having a greater number of features and functionalities in the ERP package does not imply that the ERP vendor has a profound understanding of a customer's business needs (Gardner 2000). Although the impact of software applications' shortcomings on IT project failures should not be overlooked (Sumner 2000), it should be kept in mind that software is nothing more than a tool, and enterprises must know how to use it to reach their business goals (Gardner 2000). Hence, the utilization of big data platforms and tools is not different from using ERP packages and other software applications; managers should know beforehand what they want from the features of big data platforms in order to extract the most business value.

Although one cause of failure for big data projects is focusing on technology features without clear business direction, determining which tools and techniques are best suited to extract and communicate the most pertinent insights from big data is an important challenge for IT leaders and technology specialists. In fact, big data requires IT leaders to acquire and apply the right tools, techniques, and architectures for analyzing, visualizing, linking, and managing complex big datasets (Newman 2012a). In response to such requirements for big data projects, an appropriate enterprise-wide practice will be of assistance.

III. ENTERPRISE ARCHITECTURE ASSISTS WITH BIG DATA IMPLEMENTATION ISSUES

So far, we have discussed how big data projects can fail for several reasons: a) failure to identify business goals and the misalignment of the project outcome with business requirements; b) poor planning and failure to define an adequate scope; c) lack of enterprise-wide data access and the lack of cooperation between stakeholders; d) change management issues; and e) a focus on technology capabilities rather than business requirements. All of these causes spur enterprises to look for a solution that can assist with big data implementation and produce results more rapidly, with fewer challenges, and with more confidence in driving future business insights. In large projects such as big data, which require the significant involvement of multiple stakeholders and which run across the enterprise in parallel with other projects, researchers highlight a critical problem that prevents the efficient and adequate implementation of business strategy (Hauc and Kovač 2000; Patanakul and Shenhar 2012).

Project management in enterprises has shown an evolutionary broadening of scope from an ad-hoc, single-project approach to the complex, all-enterprise management of projects and portfolios that increases the need for enterprise-level project governance. Enterprise project governance is a framework that resides under the umbrella of corporate governance and top management to ensure that all projects, programs, and portfolios are aligned with the overall business strategy, balanced with respect to corporate governance, and succeed by establishing a well-defined approach that all stakeholders understand and agree upon. It also monitors and confirms proactively that everything in projects and portfolios stays ultimately on track with creating business value for the organization (Dinsmore et al. 2012). In fact, when the projects of an enterprise are governed at the enterprise level, the success criteria of projects are not defined only by the factors of time, cost, and quality, but instead by estimating their benefits for the organization based on their impact on customers and business, the opening of new opportunities for future business, and stakeholder satisfaction (Alsudiri et al. 2013).

The existing gap in the proper implementation of strategic planning cited by researchers can be filled by applying the Enterprise Architecture practice to an organization, since based on its definition, Enterprise Architecture aims at conducting enterprise analysis, design, planning, and implementation for the successful execution of business strategy (Hauc and Kovač 2000; Patanakul and Shenhar

2012; Shenhar et al. 2007; FEAPO 2013). Figure 9 shows the intermediary role of Enterprise Architecture as a bridge between strategy formulation and strategy execution.

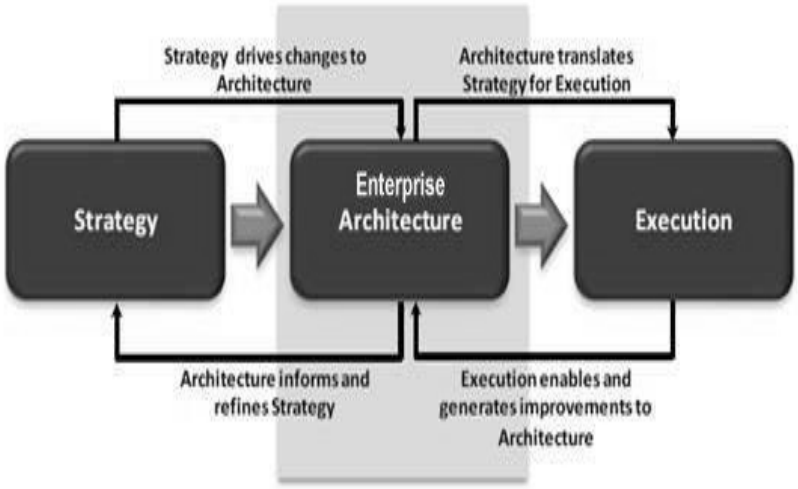

Figure 9: Enterprise Architecture as the Bridge between Strategy and Execution

At the macro level of Enterprise Architecture, the focus is on the transformation of the enterprise from its current state to a future state for implementing the business strategy. But at the micro level, projects are designed to apply the business strategy to new services, products, and processes necessary for the success and viability of the organization (Benko and McFarlan 2003). Therefore, project portfolio management and enterprise project governance are the essential disciplines of effective Enterprise Architecture in organizations (Leganza 2003). Several other disciplines are also inseparable components of Enterprise Architecture for the effective execution of business strategy, including: performance engineering and management, process engineering and management, governance and compliance, IT strategic planning, risk analysis, information management, metadata management, and a wide variety of technical disciplines, as well as organizational disciplines such as organizational development, transformation, innovation, and learning.

When expanding the scope of the Enterprise Architecture practice to encompass the architecture of the enterprise as a whole, it can be argued that all of the disciplines listed above would fall under this broad, enterprise-wide view of the Enterprise Architecture practice. If the scope of the Enterprise Architecture practice is limited primarily to the domain of the IT organization, as it is in most organizations

today, then the disciplines listed above would contribute to the EITA process but not fall completely under the domain of the Enterprise Architecture practice. However, if the scope of the Enterprise Architecture practice is intended to be the enterprise as a whole, placing these disciplines under the purview of the Enterprise Architecture practice may be warranted.

Assuming that an enterprise is benefiting from the Enterprise Architecture practice at the holistic level, the issues encountered in the implementation of big data projects could be alleviated. Considering the first cause of big data project failure is the lack of a clear business goal, we can argue that no IT project such as big data should get started without having a clear business goal beforehand since Enterprise Architecture uses project portfolio management to prioritize projects and allocate resources to them (Cameron H. 2006; Newman 2012a). Further, through the governance of IT projects including big data projects, Enterprise Architecture can assure project alignment with business strategy. To increase the possibility of a big data project's success, Kaskade (2013) suggests that enterprises define a business case with a narrow scope that has consensus across the enterprise. Enterprise Architecture can assist with this approach by analyzing different cases of departments and selecting a simple one in which all key stakeholders across the enterprise see value in its implementation.

Enterprise Architecture also contributes to appropriate planning for big data projects and defining accurate project scope because it encourages spending enough time to analyze the business objectives of a project before the planning begins, thus preventing a project from delivering a misaligned outcome. Moreover, since Enterprise Architecture creates and maintains a common vision of the future shared by both business and IT, and drives continuous alignment between them, defining the scope of big data projects will be easier for both of these stakeholders (Schekkerman 2004).

Further, Enterprise Architecture has the potential to unblock the power of information by unifying the information silos in an enterprise that hinder various stakeholders from cooperating with each other (Schekkerman 2004). In other words, architecting enterprise information essentially focuses on interoperability and the agile extensibility of information across enterprise processes. To support this objective, first it is determined which information assets should be treated as enterprise information (e.g. contents that need to be shared consistently), and then the requirements, principles, models, and data privacy policies which strengthen the network effects of sharing information assets across the enterprise can be

created or updated (Newman 2012b; Newman 2012a). Enterprise Architecture also helps to identify the cultural roadblocks to data sharing in organizations by producing stakeholder analyses and encouraging communication among them in order to overcome obstacles such as the lack of stakeholders' trust in data accuracy and integrity (Newman 2012a). Besides solving the problem of information silos and cultural roadblocks inside organizations, Enterprise Architecture will help to identify external data sources that support organizations' strategic business objectives (Newman 2012a).

The unwillingness by stakeholders to change business processes at the enterprise level is another cause of failure in big data projects. In fact, confusion and resistance soar when people must deal with radical business process transformation since it affects tasks, relationships, skills, roles, responsibilities, work outputs, organizational structure, and technology across multiple business units (Morello and Olding 2008). Therefore, organizations that couple organizational change management with an Enterprise Architecture program will avoid resistance and confusion by users, reduce frustration, and prevent implementation errors. Since change management is a critical aspect of Enterprise Architecture, it should be considered as a change facilitator that adopts formal organizational change management strategies including tools and models to channel the activities of business and technical professionals towards a unified enterprise architecture (Papegaaij and Buchanan 2010). With Enterprise Architecture enacting such a facilitator function, the necessary business process changes in big data projects will be better received by stakeholders who are more willing to accept the changes.

The last, but not least important, cause of failure in big data projects is focusing more on technology rather than business requirements. In fact, this type of failure is closely related to the first cause (no clear business goal), and the way Enterprise Architecture can support a project can help ameliorate both of the causes. When Enterprise Architecture is behind the initiation of every enterprise-wide IT project such as big data through the process of project governance, the exploration of different features of big data platforms such as Hadoop does not become the objective of the project nor an exciting part of implementing the project that eclipses the original purpose. Under the Enterprise Architecture governance, the business driver comes first, with a clarified narrow scope that propels and directs the exploration of big data platform features.

In terms of selecting the right data analytic tools that contribute to the extraction of business value out of complex big datasets, Enterprise Architecture practitioners can compare emerging big data

tools and techniques to the current capabilities of an organization to produce appropriate recommendations. Enterprise Architecture practitioners investigate whether a technology is simply hype or whether it has business value. When possible, Enterprise Architecture practitioners should seek low-cost, open source tools that can be used in the early stages to demonstrate the feasibility of big data projects (Newman 2012a). Big data projects also expose talent gaps that need to be filled with hybrid thinkers who possess multidisciplinary skills to make the best usage of big data tools. In this regard, Enterprise Architecture will assist organizations evaluate their resource planning deliverables in order to find shortcomings with current skills and identify the acquisition of needed skills such as data scientists for tackling talent gaps in leveraging big data tools (Newman 2012a).

For enabling innovation and managing rapid changes in complex global organizations, Gartner recommends the adoption of an 'EA Lite' approach, in which Enterprise Architects create the most adaptable architecture for the future, rather than creating the most complete or elegant architecture for the moment. In this approach, organizations focus on managing the dependencies between major elements of Enterprise Architecture -- whether applications, business processes, or information flows -- rather than creating a detailed, consistent architecture encompassing all the elements, which can in fact be a failure point of many inflexible, cumbersome architectures. Hence, if the architected elements conform to a minimal set of stable, generalized interfaces, they can be readily changed and coordinated, enabling rapid changes and innovation in complex organizations (Gall 2008).

In big data projects, for creating large aggregated datasets, Gartner recommends that extended enterprises join in an information commons as a community of interest that manages and governs information as a shared resource with special regard to its open and equitable access, use, and sustainability (Newman 2010). Such an alliance among complex organizations enables members of the community to share infrastructure costs and use their co-created big data pool for testing and uncovering new insights. This way, members of the community will cooperate to co-create big data pools but then compete to extract value from them (Newman 2012a).

IV. CONCLUSION

Organizations today are undergoing a revolution driven by the use of data and analytics to guide their decision making due to the rapid

proliferation of the data available to be analyzed (Gopalkrishnan et al. 2012; Singh and Singh 2012). In fact, the promise of big data is enabling organizations to exploit the growing volume, velocity, variety, and complexity of data both inside and outside the enterprise, and to find unique patterns by linking sources once hidden within deeper Web resources (Newman 2012a). Statistics show that 81% of enterprises, from small- to large-sized, rank big data analytics projects among their top-five IT priorities (Kaskade 2013). However, more than half of these big data projects aren't completed, and many others fall short of their objectives (Kaskade 2013; Eastwood 2013). The current literature on big data predominantly focuses on the technical issues of providing a platform for big data analytics, while issues relevant to big data project management have not yet been addressed. Hence, in this report the possible reasons behind failure of big data projects were explored, and it was suggested how the practice of Enterprise Architecture could alleviate these problems. The root causes behind the failure of big data projects are the following:

1. Having no clear business goal and the misalignment of the project outcome with business requirements;
2. Poor planning and the lack of an adequately defined scope;
3. The lack of enterprise-wide data access and the lack of cooperation between shareholders;
4. Change management issues; and
5. Focus on technology capabilities rather than business requirements.

The practice of Enterprise Architecture is a bridge between strategic planning and strategy execution, as it aims to conduct enterprise analysis, design, planning, and implementation for the successful execution of business strategy (FEAPO 2013). In fact, Enterprise Architecture provides the holistic information and insights needed for more effective decision making in organizations to improve their effectiveness, efficiency, and agility. Although from the macro perspective, Enterprise Architecture focuses on transformation of the enterprise from its current state to a future state to implement the business strategy, from the micro perspective, projects manifest the application of business strategy to new services, products, and processes necessary for the success and viability of the organization (Benko and McFarlan 2003). Therefore, the successful transformation of an enterprise is partly based upon the success of projects implemented enterprise-wide, including big data. The practice of

Enterprise Architecture can utilize several disciplines such as project portfolio management and enterprise project governance to avoid the pitfalls in big data projects.

To conclude, we summarize the previous discussion of how Enterprise Architecture can support successful big data project implementation enterprise-wide by utilizing important disciplines and traditional areas of focus. Because Enterprise Architecture uses project portfolio management to prioritize projects and allocate resources to them, it will prevent big data projects from getting started without having a clear business goal in advance, thus avoiding the primary cause of big data project failure (Cameron H. 2006; Newman 2012a). Furthermore, Enterprise Architecture governance of big data projects will assure that the project outcomes are aligned with business strategy.

Concerning the second cause of failure in big data projects, Enterprise Architecture contributes to appropriate planning for big data projects and the accurate definition of project scope by reserving enough time to analyze business objectives of the project before planning is started. Moreover, through driving continuous alignment between business and IT units, the practice of Enterprise Architecture facilitates defining the scope of big data projects for both of these stakeholders (Schekkerman 2004).

Regarding the third cause of failure in big data projects, Enterprise Architecture unblocks the power of information by unifying the information silos in an enterprise that hinder various stakeholders from cooperating with each other (Schekkerman 2004). It also helps to identify the cultural roadblocks to data sharing in organizations by producing stakeholder analysis and helping communication among them to overcome obstacles such as the lack of stakeholders' trust in data accuracy and integrity. Enterprise Architecture will also assist with identifying external data sources that support an organization's strategic business objectives (Newman 2012a).

In tackling change management issues in big data projects, organizations that couple organizational change management with an Enterprise Architecture program avoid resistance and confusion from users by adopting formal organizational change management strategies (Papegaaij and Buchanan 2010). This way, the necessary business process changes in a big data project will not seem to be a faulty process to stakeholders, so they should be more willing to accept the changes.

To alleviate the last cause of failure in big data projects, since the practice of Enterprise Architecture governs project initiation, it will not allow a big data project to get started blindly by focusing only on

technology capabilities without knowing the business drivers. However, by selecting the right data analytic tools, Enterprise Architects investigate whether a technology is simply hype or has business value. They also attempt to understand the benefits and risks of each technology approach to assist big data project leaders in the selection of the right data analytic tools to extract business value out of complex big datasets.

Big data projects also expose talent gaps that need to be filled with hybrid thinkers possessing multidisciplinary skills for making the best use of big data tools. In this regard, Enterprise Architecture will help organizations evaluate their resource planning deliverables in order to find the talent gaps and determine the skills they need to acquire, such as data scientists, for leveraging big data tools (Newman 2012a).

In summary, in the age of big data, the task for Enterprise Architecture practitioners is to design business outcomes that exploit big data opportunities both inside and outside the organization. According to Newman (2012b), those teams of Enterprise Architecture practitioners who strengthen their Enterprise Architecture practice by focusing on its role in delivering business value and the strategic use of information, including big data, are more successful at driving effective change in organizations.

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